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LIVESTOCK-FISHERY INTERACTION STUDIES

BIG CREEK, UTAH

Progress Report 2 to the USDI Bureau of Land Management, Salt Lake
District Office, Salt Lake City, Utah

June 1980 to May 1981

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ABSTRACT

Big Creek exhibits the positive effects of restricting livestock impacts on riparian vegetation and streambanks. With the related exceptions of excessive fine channel sediments, high channel substrate embeddedness, and correspondingly reduced fish populations, the riparian and fishery habitat within the ungrazed area is markedly superior to similar habitats in the grazed pasture. The negative features inside the ungrazed area are suspected to result from the improper functioning of instream habitat improvement structures which, while improving pool abundance and apparent quality, may have increased sediment deposition. Further trend analysis will help clarify these interacting forces. The present continuous grazing system on Big Creek will be changed in 1981 to a deferred system. The continuance of this study will allow a determination of the ability of this new system to protect and enhance the already impacted riparian-stream environments.

ACKNOWLEDGEMENTS

This progress report represents the study and integration of informative material from various sources. Except as otherwise noted, however, all specific data pertaining to the Randolph Planning Unit and the Big Creek Allotment prior to the initiation of this study was obtained from the Randolph Planning Unit Grazing Management Final Environmental Statement, USDI, Bureau of Land Management, Salt Lake District, Salt Lake City, Utah; therefore, in order to keep unwieldy referencing to a minimum, this publication is only cited where absolutely necessary.

Special appreciation is extended to Gerry Ferringer, State Fishery Biologist, USDI, Bureau of Land Management, Utah State Office, Salt Lake City, Utah, help in coordinating this study; to Dave Bornholdt, Fisheries Biologist, USDI, Bureau of Land Management, Salt Lake District Office, Salt Lake City, Utah, for his efforts in providing technical information; to Dexter Pitman, Regional Fisheries Manager, Utah Division of Wildlife Resources, Northern Regional Office, Ogden, Utah, for his assistance in organizing the fish population analysis of Big Creek; to D. Cal McCluskey, Wildlife Biologist, USDI, Bureau of Land Management, Salt Lake District Office, Salt Lake City, Utah, for technical information and photographs of Big Creek; and to Dave Young, Fisheries Biologist, USDI, Bureau of Land Management, Sevier River Resource Area, Richfield, Utah, for photographs illustrating field techniques.

PREFACE

This is the second in a series of progress reports that present the results of The Big Creek, Utah, Livestock-Fishery Interaction Studies, and is intended to supplement Progress Report 1 (Platts, Nelson, and Martin, 1980). We have included sufficient information in this report for it to stand alone and to provide a comparison of results from 1979 and 1980; the reader may, however, wish to refer to Progress Report 1 for a more comprehensive presentation of the results obtained in 1979.

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INTRODUCTION

There are 1.9 billion acres of land in the 48 conterminous United States, of which some 1.2 billion (63 percent) are rangelands; as of 1970, 69 percent of this range was grazed by domestic livestock. In the western United States, most of these rangelands are public lands administered by federal agencies. In Utah, for example, 66 percent of the state is federally owned and of this, some 24 million acres (43 percent) are administered by the USDI, Bureau of Land Management (BLM)^{1/}.

Many streams of various sizes traverse this vast area, but despite their prevalence (Utah, for example, has some 2500 miles of stream on BLM land) they represent relatively little acreage. These streams, together with their adjacent riparian zones, contribute significantly to the productivity of the range, especially in arid and semi-arid regions, and present unique problems in multiple use management. Unfortunately, this fact has only recently become widely appreciated and streams and riparian zones have frequently been ignored in rangeland planning and management in the past, largely due to their small relative size.

The various classes of livestock utilize the range in different ways, necessitating different management practices to increase the compatibility of each class with riparian and aquatic habitat. Cattle, for example, will congregate on lesser slopes and bottomlands, while sheep, which are less dependent on water, usually favor steeper slopes and upland areas (Stoddart and Smith 1955). Since sheep are also usually herded whereas cattle are not, management techniques to keep watersheds from being significantly altered differ between these two classes of livestock. The commonly used cattle management techniques are suspected to be less congenial than those used with sheep and are therefore the focus of this study.

Since the riparian zone, which forms the interface between the aquatic and terrestrial range ecosystems, is disproportionately important to both areas, effective management of the riparian zone is critical. Because of soil moisture, soil fertility, and related factors, the riparian ecosystem is more productive than the adjacent, drier upland range, and its vegetation is more palatable. Coupled with this are other riparian features, such as gentler terrain, increased shade, and drinking water, which add to the attractiveness of the riparian zone to cattle and lead to preferential use.

The riparian zone also provides critical fishery habitat components which are largely determined by streamside vegetation. Overhanging vegetation and undercut streambanks are an important source of protective cover, food, and shade. Shading prevents water temperatures

^{1/}Duff, D. 1980. Personal correspondence. USDA, Forest Service, Intermountain Regional Office, Ogden, Utah.

from rising or fluctuating drastically, which can lead to shifts in species composition from salmonids to more tolerant species of non-game fish (Platts 1980). In addition, detritus formed from terrestrial plants is a principal source of food for aquatic invertebrates and ultimately fish (Minshall 1967). Streamside vegetation also serves as a barrier to terrestrial pollutants and controls water velocity and streambank erosion. Since these features are all susceptible to alteration by grazing animals, the needs of the resident fishery and the stockman can conflict.

Presently, there is an unfortunate dearth of factual information regarding the impacts of livestock grazing on riparian and aquatic ecosystems. As yet, only limited research has been directed toward lessening these impacts, though the constant increase in range use by cattle since the late 1800's has generally degraded rangelands and led to altered riparian habitats (Platts 1978). The resulting controversy surrounding the use of public rangelands by livestock and its potential conflicts with fishery needs has led to the emergence of livestock management as a national environmental issue (Leopold 1975; Platts 1978).

Working in this information vacuum, fisheries biologists have intuitively hypothesized that grazing of the riparian zone can significantly alter a fishery. Such alteration is believed to occur through physical modification of key stream features. Such changes as channel broadening, decreases in depth and pool-riffle ratio, loss of vegetative and structural cover, accelerated bank erosion and sedimentation, increased water temperature, and related factors are expected to modify the character of the fishery. These changes, however, have yet to be sufficiently evaluated and identified for routine inclusion in management strategies. Additional studies that will provide solutions to these potential problems must be conducted (Meehan and Platts 1978).

Against this background of limited information, it should come as no surprise that little help can be given the land manager in determining alternate strategies in situations where livestock are known to be exerting undue stress on the fishery. Valid analytical techniques for assessing the magnitude of livestock impacts have yet to be fully developed. Without these tools, it is difficult to determine whether changes in grazing patterns are indicated and what strategies should be implemented.

The Big Creek study is part of a comprehensive program to develop an array of field techniques coupled with computer analysis that will accurately identify the complex interactions that occur between different grazing intensities and classes of livestock and fish. Field studies are currently being conducted on eleven sites in Idaho, two sites in Nevada, and two sites in Utah (Figure 1). The Idaho studies monitor impacts to streams in moist, forested, high mountain meadows, while the Utah and Nevada studies monitor impacts to streams in the more arid sagebrush type meadows. These studies are structured to allow

IDAHO BATHOLITH

- 1 Lower Stolle
- 2 Cougar Stolle
- 3 Guard Stolle
- 4 Upper Stolle
- 5 Johnson Creek
- 6 Elk Creek
- 7 Lower Bear Valley
- 8 Upper Bear Valley
- 9 Lower Frenchman Creek
- 10 Upper Frenchman Creek
- 11 Spring Creek

HUMBOLDT RIVER BASIN

- 12 Gance Creek
- 13 Tabor Creek

BONNEVILLE BASIN

- 14 Big Creek
- 15 Otter Creek

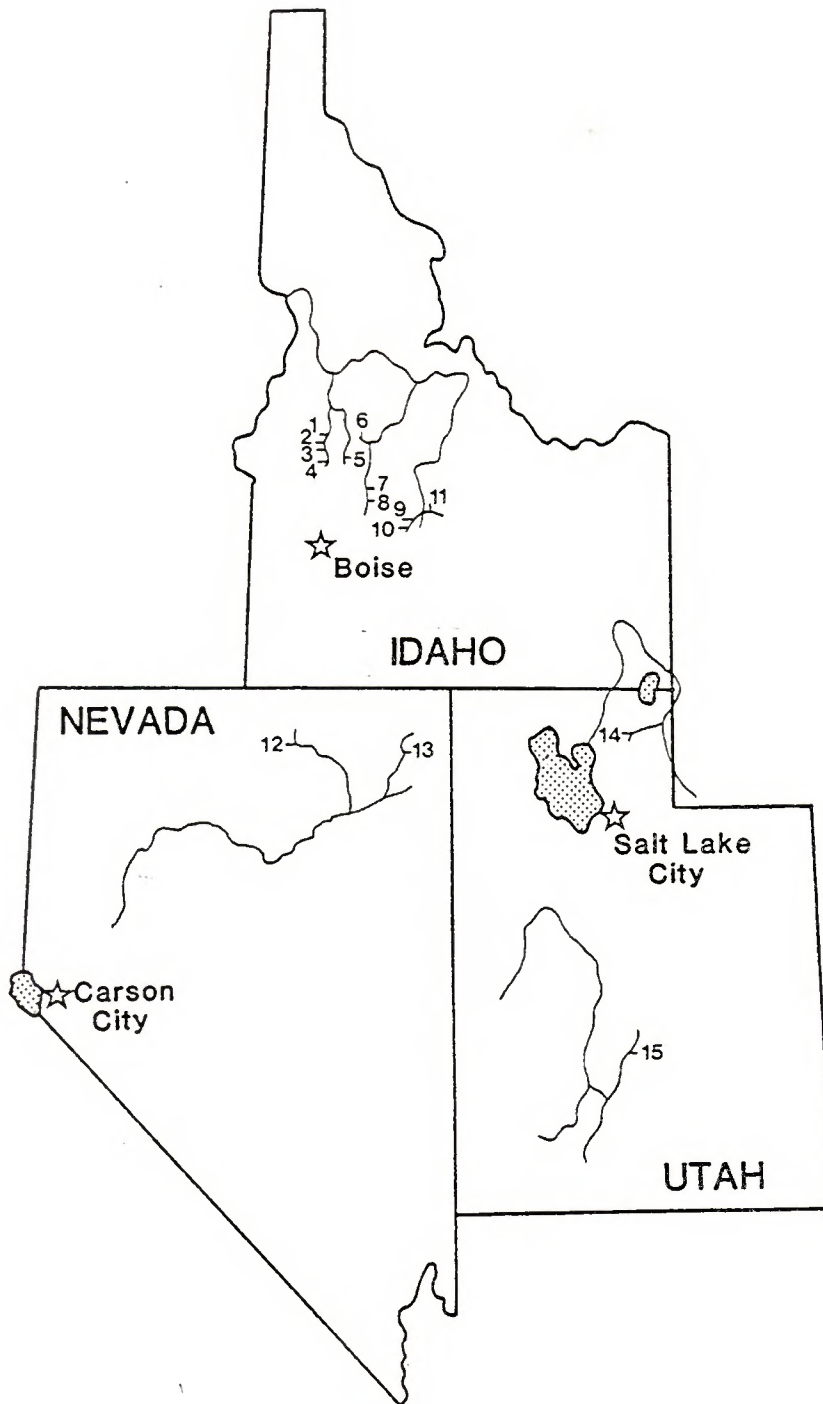


Figure 1. Distribution of livestock-fishery study areas.

time-trend analysis of livestock impacts on streams and will help the land manager select grazing systems that are as compatible as possible with fishery needs.

This progress report deals exclusively with the Big Creek, Utah study which has the following objectives:

1. Determine the rehabilitation potential of Big Creek based on past, present, and future use strategies.
2. Evaluate the improved management techniques proposed by the BLM.
3. Evaluate the continuous grazing system currently in use on the Big Creek Allotment.
4. Make recommendations regarding optimum grazing strategies relative to use of riparian forage.

STUDY AREA DESCRIPTION

Randolph Planning Unit

The Randolph Planning Unit comprises much of Rich County, the completely rural corner of extreme northeastern Utah adjacent to the Idaho and Wyoming borders (Figure 2). This is the Bear River drainage basin, which is a tributary of the Bonneville Basin of Western Utah, part of the Great Basin of the Intermountain region of the western United States. Physiographically, this region is also part of Bailey's (1978) Wyoming Basin Province because of its separation from the Great Basin by the Wasatch Mountains. It is an area of variable relief, consisting primarily of gently rolling hills covered by vegetation typical of the northern desert shrub lands, but it also includes forested mountains, alkaline bottom lands and flood plains. The climatic regime is representative of such steppes, with cold winters and short hot summers. Precipitation averages from 10 to 14 inches, making the region semi-arid, and falls mainly in the winter and spring. Summer thunderstorms are generally violent with little rainwater absorbed into the ground water supply, so vegetation development is largely dependent on snow accumulation and subsequent gradual release of meltwater. Many plant species exist in the area, but because of local variations in relief, precipitation, temperature, historic use pattern, and edaphic conditions, the dominant plant association is the sagebrush-wheatgrass typical of this ecoregion.

The planning unit itself comprises 569,102 acres, of which 170,583 acres are public lands administered by the Bureau of Land Management. It is divided into 19 grazing allotments, which are composed of a mixture of public, private and state lands. Typically, the fertile valleys are privately owned while the sagebrush uplands represent the public domain.

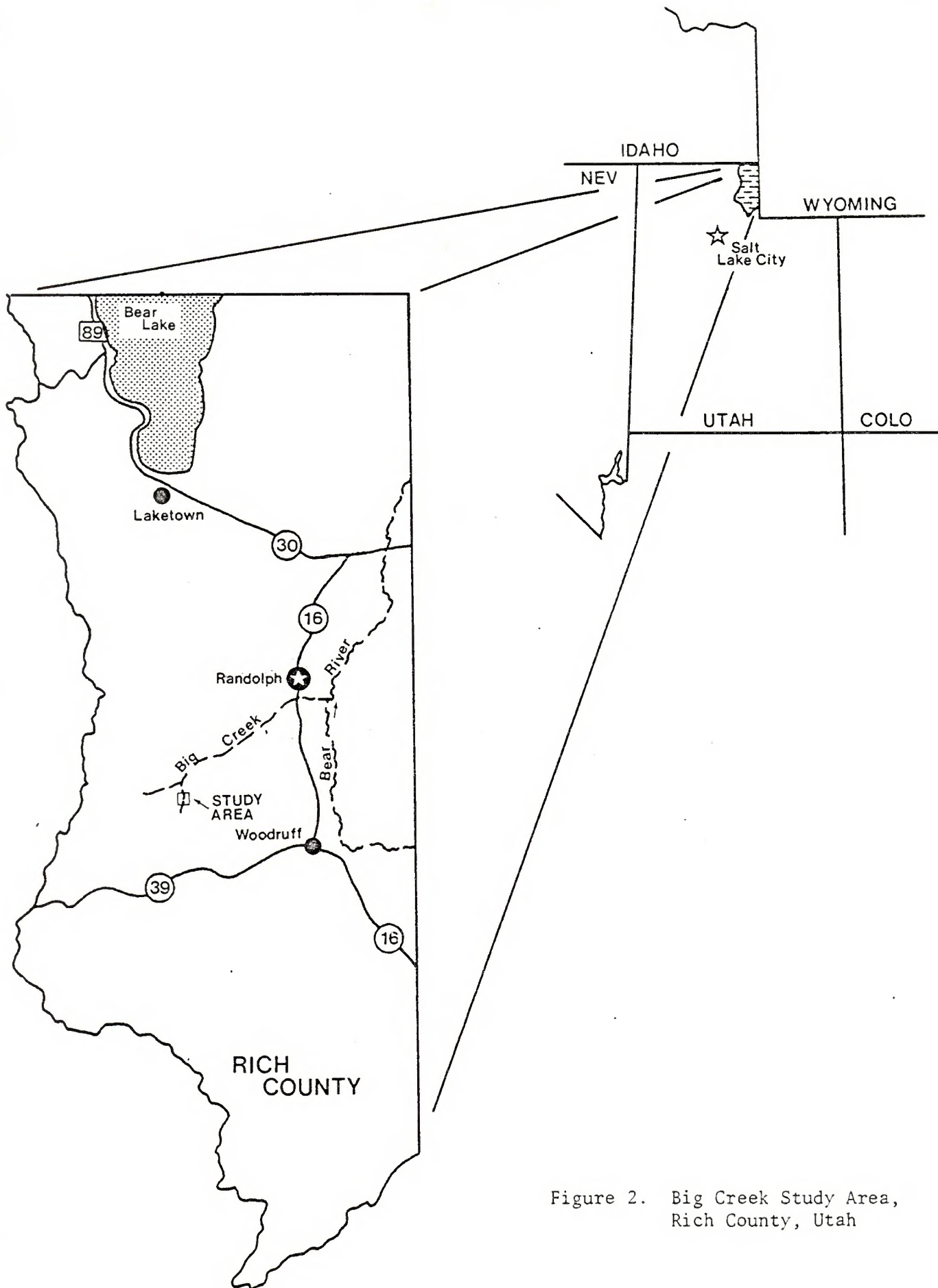


Figure 2. Big Creek Study Area, Rich County, Utah

Since Rich County was settled in 1870, agriculture, especially cattle production, has been the chief industry. In semi-arid regions such as this, the best lands have typically been cultivated and thus removed from grazing, making the shrubby uplands extremely important to the livestock industry. Critical spring and fall range is generally deficient in the cultivated areas, but can be provided by the uplands (Stoddart and Smith 1955). Since these less-arable uplands constitute the public lands of the Randolph Planning Unit, grazing of public lands is an important economic issue.

Big Creek Allotment

Big Creek is the third largest of the 19 grazing allotments in the Randolph Planning Unit, and is located immediately southeast of the city of Randolph (Figure 2). Its 33,255 acres include two perennial streams, Randolph Creek and Big Creek. The latter is currently being studied by the BLM to assess livestock impacts on riparian and aquatic habitat. Part of the allotment has been fenced to exclude cattle from 0.6 miles of stream, so that time trends in stream deterioration or rehabilitation can be monitored. This enclosure currently represents the only stream reach in the planning unit rated by the Bureau to be good fishery habitat (Figures 3 and 4), and is populated by rainbow trout (*Salmo gairdneri*), yellowstone cutthroat trout (*Salmo clarki bouvieri*), sculpin (*Cottus sp.*) and sucker (*Catostomus sp.*); stocking by the Utah Division of Wildlife Resources helps maintain game fish populations.

THE SITUATION

Range Habitat

The land surrounding Big Creek is a semi-arid shrubsteppe. As is generally the case in ecosystems controlled by abiotic factors, the plant and animal communities are dominated by a few very abundant species. In this instance, the rolling hills support an almost uniform growth of big sagebrush (*Artemisia tridentata*), a plant of relatively little forage value for livestock. This vegetation type, of which 75% is this one species, accounts for 65% of the BLM land in the planning unit; surprisingly, despite this abundance big sagebrush may not even be the natural dominant in many cases. The second most abundant vegetation type in the planning unit as a whole is bunchgrass, represented chiefly by the exotic, palatable, crested wheatgrass (*Agropyron cristatum*), which accounts for only 9.1% of the vegetation.

Sagebrush, though undoubtedly an important component of the natural climax vegetation, may not naturally be the dominant it now is. Considerable evidence exists which points to grazing-induced vegetation shifts being the cause of its present dominance over much of the western range (Bailey 1978; Christensen and Johnson 1964; Christensen 1963; Stoddart and Smith 1955; USDA 1936). Christensen (1963), in fact, reporting on undisturbed stands of grasses dominated by bluebunch wheatgrass (*Agropyron spicatum*) in central Utah, states that sagebrush is rarely dominant in areas protected from grazing. From such evidence,



Figure 3. Stream reach in the central portion of the existing livestock enclosure. Note the abundance of grass on the banks and dense brush beyond the fenceline.

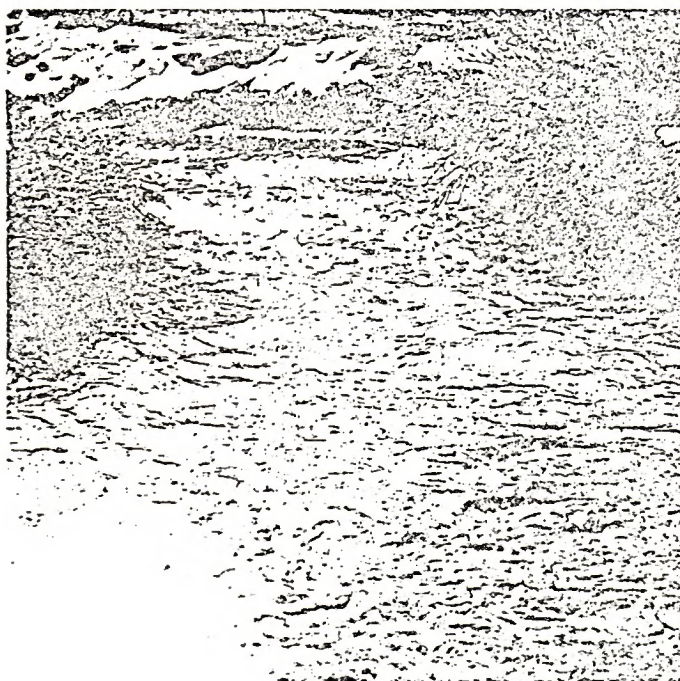


Figure 4. Stream reach in the upper section of the enclosure. Note the overhanging grasses and the willow on the right bank.

it seems likely that in northeastern Utah, which is subject to considerable influence from the Great Plains to the east, much of the land now dominated by sagebrush would be climax grassland in the absence of grazing.

Normal plant succession progresses toward a climax type that is most stable relative to ambient conditions. Disruptive forces or long term changes in ambient conditions can modify this sequence, however, favoring another species composition. In the intermountain region, cattle may represent such a long term change in ambient conditions, selectively exerting grazing pressure on the bunchgrasses relative to the sagebrush. Coupled with a history of range overuse, a shift in species composition toward big sagebrush dominance is to be expected. Thus, the quality of the range deteriorates in response to grazing pressure, possibly maintaining big sagebrush as a grazing disclimax.

In order to control this retrogressive succession, various management techniques are used. These include herbicide applications and burning to reduce brush cover, as well as various pasturing techniques to directly reduce grazing pressure at certain times.

Riparian Habitat

In the Randolph Planning Unit, riparian vegetation accounts for only 0.7% of the BLM land. Because of this, it is easily and often overlooked in range planning. This highly productive zone that separates the aquatic ecosystem from the terrestrial range ecosystem is far more important than its low relative abundance would suggest. In fact, the Randolph Planning Unit Environmental Statement (USDI 1979) states that aquatic/riparian and fisheries habitat may be the most important habitat type in Rich County. It's importance comes from the fact that crucial resources for wildlife, livestock, water quality, and fish are provided by this zone. For livestock the riparian zone provides water, generally moister more palatable vegetation, gentle terrain, and shade.

Since cattle may preferentially graze riparian vegetation, the riparian zone can be expected to be heavily used under any grazing system. If historical use patterns have led to general range deterioration, it is only reasonable to expect at least equal alteration of riparian habitat. Congregation of cattle along streambanks can modify the habitat through such direct physical action as reduction of streamside vegetation and bank trampling. These, in turn, can lead to decreases in overhanging cover, streambank stability, pool quality, pool-riffle ratio, and overall water quality. If shifts in riparian species composition parallel such shifts in upland range vegetation, selection for a grazing dis-climax in the riparian zone may also have occurred. This is important, because not all plants provide equal cover or bank stability.

Management Considerations

The preceeding discussion brings up the question of management. There are basically five systems of livestock management used to control the distribution of livestock over the range. These systems are continuous or seasonal grazing, rotation grazing, deferred grazing, deferred rotation grazing, and rest-rotation grazing (Meehan and Platts 1978). These commonly used systems are designed to increase range plant vigor, and thus help rangelands recover from historical abuse. Their effectiveness in promoting recovery of riparian vegetation, however, needs clarification.

Continuous grazing is common in the Randolph Planning Unit, and consists of stocking an allotment in the spring and removing the animals in the fall. It is almost a no-management system, except that timing of stocking and removal can be manipulated so as to avoid critical developmental stages of the forage plants. Nevertheless, it is an unsuccessful system, as noted by Hormay (1970) who states that under continuous grazing at any stocking level, the more palatable and accessible plants will be killed or eliminated.

Another popular grazing system is rest-rotation grazing, which subdivides an allotment into pastures which are then systematically grazed and rested. If correctly applied, this system can help restore the vigor of range plants, with the amount of rest required being determined by characteristics of the forage plants involved (Hormay 1970). Whether this system can benefit riparian vegetation, however, is still open to question and there are, in fact, indications that it cannot help the recovery of abused riparian habitat. Meehan and Platts (1978) suggest that this system may be harmful to riparian ecosystems because of increased potential for livestock movement and use of the riparian zone. A study by Starostka^{2/} on Seven-Mile Creek, Utah, suggests that not only may riparian habitats not be improved under a rest-rotation system, but increased production of riparian vegetation following a year of rest may increase the attractiveness of this zone to cattle. This could accelerate modification of the riparian zone since structural damage does not recover as rapidly as vegetation (Figure 5), nor do all plant species recover at the same rate. In an on-going BLM study, Duff (1977, 1978) found that woody vegetation along Big Creek recovered more slowly than grasses, and that only 6 weeks of grazing were required to return the riparian habitat within the Big Creek exclosure, which had been rested for four years, to pre-rest conditions.

The three other systems either defer grazing for parts of the season or are combinations of seasonal deferment and resting; none have clearly been shown to be effective in helping riparian vegetation recover though some may be more successful than others. Only one system

^{2/}Starostka, V. J. (n.d.) Some effects of rest-rotation grazing on the aquatic habitat of Seven-Mile Creek. Report on file USDA, Forest Service, Richfield, Utah.

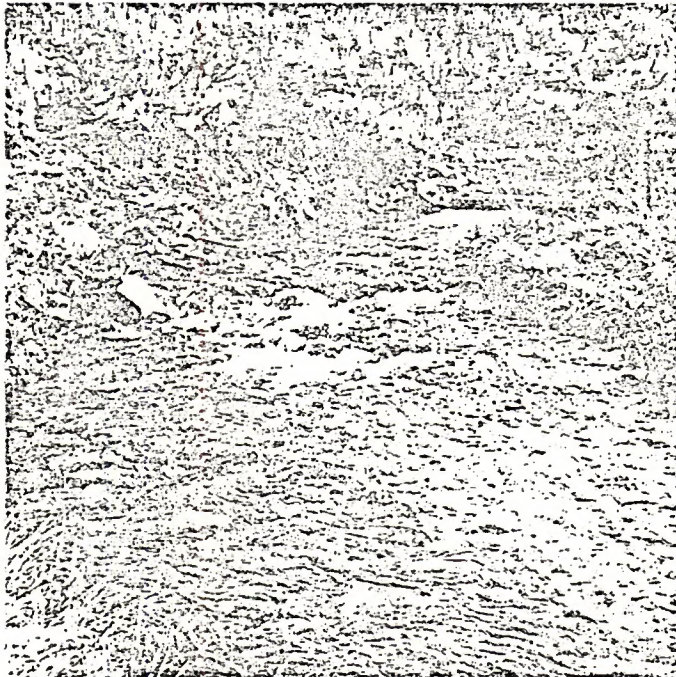


Figure 5. Stream reach in the lower portion of the enclosure. This area experienced some trespass use in 1979. Note the bank sloughing as well as the grasses interspersed among the shrubs.

clearly stands out as being useful in riparian recovery: complete rest. This can be accomplished by fencing, as the BLM intends to do on some stream reaches in the Randolph Planning Unit, and though it cannot be the final solution it must be a consideration if high quality riparian habitat is to be conserved. The answer to this vexing problem should become clearer as this study progresses, since it will monitor three grazing systems: non-grazing in the exclosure, the continuous system that has been historically used, and the deferred-rotation system to be implemented by the BLM to improve range conditions. The deferred-rotation system will allow some rest during the grazing season for each of the three pastures which make up the Big Creek allotment.

GRAZING PATTERNS

History

Since settlement of Rich County in 1870, livestock production has remained the number one industry. This has primarily been represented by various sizes of cow-calf ranching operations, ranging from small operations averaging 65 head to large operations averaging 536 head. Because the allotments are used for spring to early winter grazing, the rancher must have sufficient winter forage for his cattle. For this reason, base property is used to determine the grazing preference which for the Big Creek Allotment is potentially 4045 AUM's (not including suspended non-use).

The present grazing preference of 6742 AUM's is the result of a 40% reduction in use over the three years 1961 through 1963. Subsequent to this reduction, readjudication sub-divided the Randolph Grazing Unit into the Big Creek and New Canyon Allotments. Of the 6742 AUM's potentially allocated for the Big Creek Allotment, 2697 were put into suspended non-use, leaving 4045 AUM's in active status. As can be seen from Table 1, however, the tendency has been for authorized use to be a lesser amount.

The historic management system for the Big Creek Allotment, and presumably the older Randolph Grazing Unit, has been an allotment-wide continuous system. This system normally provides no rest period for any part of the allotment during the grazing season, but in this case a drift fence built across the lower portion of the allotment defers ^{3/} grazing on the upper two-thirds of the allotment early in the season^{3/}. Application of this system results in stocking the allotment in early May without regard to development of the key forage species, and removal after attainment of permitted use. The level of use has been 3478 cattle AUM's reached in mid-September and 402 sheep AUM's reached in late-December. It should be noted that use intensity in AUM's is a

^{3/} Anderson, G. (1979 unpublished). Big Creek allotment, grazing history and recommendations for MFP-3 decisions. (Data on file, USDI, BLM, Salt Lake Dist. Office, Salt Lake City, Utah).

function of animal numbers and time on the range; it gives no direct indication of vegetation use, which has consistently been heavy on the following scale:

Slight	0 - 10%
Light	11 - 40%
Moderate	41 - 60%
Heavy	61 - 80%
Severe	81 - 100%

Such heavy use has, in turn, led to generally deteriorated range conditions, as evaluated by the 1978 range trend survey, which shows 61% of the range in static condition and 39% declining^{4/}. Since 1978 was not a drought year and precipitation during the crop year was near normal, it is unlikely that this downward trend is a climatic artifact.

The Bureau of Land Management has determined that under present range conditions only 3116 AUM's forage are actually available to livestock, suggesting that the allotment has consistently been overstocked (Table 1) and necessitating a 25% reduction in stocking level. The range vegetation use was 65% for the years 1976, 1977, and 1978, 15% greater than the desired use of 50% for grasses and well into the heavy use level. Since riparian vegetation is frequently grazed more heavily than the dryer range vegetation, the possibility exists that riparian vegetation has been utilized at the severe level. At the very least, this system can be expected to have led to a considerably altered riparian habitat.

In order to assess the damage to the riparian habitat and its ability to recover when removed from grazing pressure, the BLM constructed an enclosure on the Big Creek allotment to exclude 0.6 miles of the stream from grazing. Despite the occasional occurrence of trespass use, particularly in 1974 when aquatic and riparian conditions reverted to pre-rest conditions as a result of heavy use, the riparian and aquatic habitats have recovered markedly (Duff 1977, 1978). Trespass use again occurred in 1979, though apparently not quite as heavily. This small section of Big Creek presently accounts for all of the fishery habitat in Rich County that the BLM considers to be in good condition.

Present and Future Trends

The BLM is attempting to apply improved management of livestock on the Big Creek Allotment, but the changes proposed in the Randolph Planning Unit Grazing Management Final Environment Statement (USDI 1979)

^{4/}Anderson, G. (1979 unpublished). Big Creek allotment, grazing history and recommendations for MFP-3 decisions. (Data on file, USDI, BLM, Salt Lake Dist. Office, Salt Lake City, Utah).

Table 1.--Livestock management, Big Creek Allotment, Rich County, Utah.

GRAZING PARAMETER		YEAR										
		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Allotment Acreage		20346	20346	20346	20346	20346	20346	33255	33255	33255	33255	33255
Grazing System		2/ AWC	AWC	AWC	AWC	AWC	AWC	AWC	AWC	3/ 4PD	4PD	4PD
Active Authorized Use (AUM) ^{5/}	Cattle	3478	3478	3478	3478	3478	3613	3804	3804	4/ N.D.	N.D.	N.D.
	Sheep	402	402	402	402	402	430	519	519	N.D.	N.D.	N.D.
	Total	3880	3880	3880	3880	3880	4043	4323	4323	N.D.	N.D.	N.D.
Stocking Date		5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	N.D.	N.D.	N.D.
Removal Dates	Cattle	9/15	9/15	9/15	9/15	9/15	9/15	9/15	9/15	N.D.	N.D.	N.D.
	Sheep	12/31	12/31	12/31	12/31	12/31	12/31	12/31	12/31	N.D.	N.D.	N.D.
Range Vegetation Use		Heavy (65%)	Heavy (65%)	65%	65%	65%	Moderate	N.D.	N.D.	N.D.	N.D.	N.D.
Riparian Vegetation Use	Inside Enclosure	Heavy	Slight	Slight	Slight	Slight	17%	0	N.D.	N.D.	N.D.	N.D.
	Outside Enclosure	Heavy	N.D.	N.D.	N.D.	N.D.	75%	82%	N.D.	N.D.	N.D.	N.D.

1/ Management after 1981 is subject to development of an interim management plan that is currently being drafted.

2/ Allotment-wide continuous (seasonal).

3/ 4-pastured deferred.

4/ N.D. - No Data

5/ 1974 - 1978 Values represent a five year average.

are currently undergoing revision. The new proposals will probably involve a four-pasture^{5/} deferred grazing system on the expanded allotment as shown in Table 1^{5/}, but specific information is lacking at this time.

The newly proposed grazing strategy may improve the aquatic and riparian habitat within the allotment, and these studies will determine if this hypothesis is rejected or not. The purpose of the new grazing strategy however, will probably improve overall range conditions, not fishery habitat in particular (as was the case under the ES), except on those stream reaches on which additional livestock exclosures will be constructed (USDI 1979); this includes 2.9 miles on Randolph Creek in the allotment.

METHODS

General

Ongoing studies are presently being conducted on a total of 15 study sites, 11 in Idaho and two each in Nevada and Utah. These sites are generally in meadow environments on National Forest lands, and lower elevation sagebrush type meadows on Bureau of Land Management lands. The purpose of these studies is to refine techniques for monitoring and assessing the impacts of livestock on riparian and aquatic ecosystems.

The basic design of each study site is to stratify 1800 feet of stream reach into 181 transects at 10-foot intervals. The stream reach is then sub-divided into three 600-foot sections, the middle section fenced to provide an area for manipulation with the two outer sections serving as up- and downstream controls. Livestock are then either introduced to or excluded from the fenced area depending on the goals of the individual study. Annual monitoring of each section then provides information on each relative to the others over the course of several seasons of use.

This design has been modified for the Big Creek study to compensate for the nature of the existing exclosure, which is one-half mile long as opposed to the 600 feet called for in the fishery study methodology. To account for this, only the lower and middle sections are continuous with transects 1 through 122 inclusive. The exclosure fenceline is between transects 61 and 62. Upstream and beginning immediately above the fenceline of the exclosure are transects 122 through 183. Figure 6 gives a schematic description of this arrangement.

The data collected fall into four basic categories: 1) geomorphic or aquatic, 2) riparian or streamside, 3) hydrologic, and 4) biological, and comprise the following:

^{5/}Yardley, C. 1981. Personal correspondence, USDI, BLM, Salt Lake District Office, Salt Lake City, Utah.

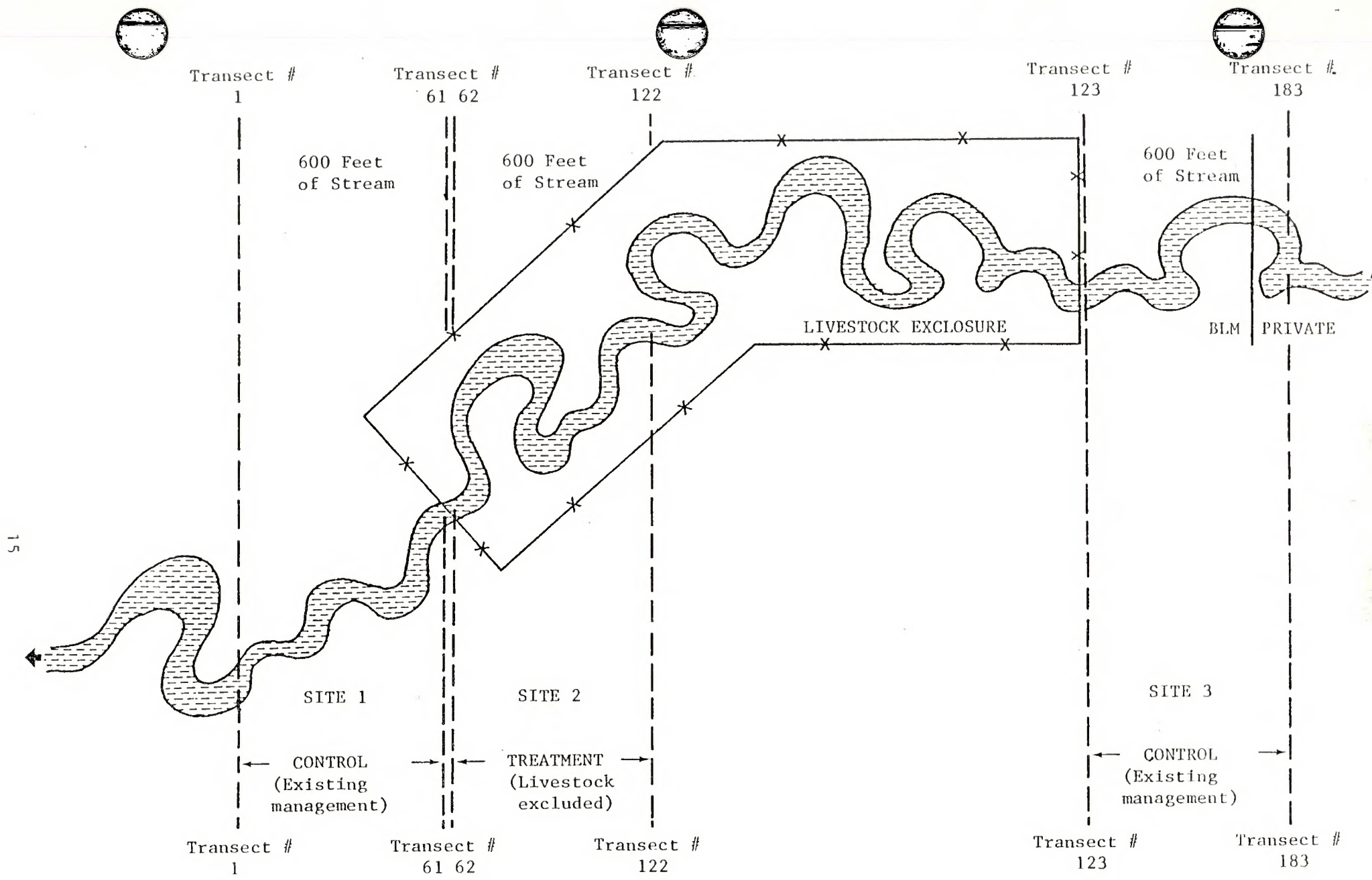


Figure 6. Schematic illustration of the livestock exclusion and the Livestock-Fishery Interaction Study design, Big Creek, Utah.

Geomorphic/Aquatic

1. Substrate materials
2. Substrate embeddedness
3. Stream width and depth
4. Bank-stream contact water depth
5. Pool width and quality and feature
6. Riffle width
7. Streambank angle
8. Streambank undercut
9. Fisheries environment quality rating

Riparian

10. Streamside habitat type
11. Streambank stability
12. Overhanging vegetation
13. Vegetation use (ocular and herbage meter)
14. Streambank alteration (natural and artificial)

Hydrologic

15. Stream profile
16. Stream gradient
17. Stream velocity

Biological

18. Fish species composition, number and biomass

A brief description of the procedures used in this study follows. More detailed descriptions can be found in Morris and others (1976), Neal and others (1976), Platts (1974), Platts (1976), Ray and Megahan (1978).

Geomorphic/Aquatic Analysis

These measurements describe the physiography of the stream being studied and can therefore be used to document livestock induced structural changes when monitored over several grazing seasons. Geomorphic/aquatic measurements are analyzed statistically to determine means, variances, standard deviations, standard errors, 95 percent confidence intervals, student's T values, and F values for each variable in each study site.

Water Column

Stream width is a horizontal measurement of that area of the transect covered by water. Stream depth is the average of four water depths taken at selected intervals across the transect from the water surface to the channel bottom. Water depth at the intersection of the streambank or stream channel with the edge of water is a direct measurement from water surface to channel bottom. Pools are classified as that area of the water column usually deeper than riffles and slower in water velocity. Riffle is the remainder of the column. Pool quality rating is based on the pool's ability to provide certain rearing requirements of fish, such as width, depth, and cover.

Streambanks

Streambank alteration readings attempt to quantify the natural and artificial changes occurring to the streambank, and are given as a percentage. The streambank angle is measured with a clinometer (Figures 7 and 8), which determines the downward slope of the streambank to the water. Streambank undercut is a direct horizontal measurement, parallel to the stream channel, of the erosion of the bank at the water influence area. Fisheries environment quality ratings depict the general ability of the bank-stream contact zone to provide the conditions believed necessary for high fish standing crops. This rating is a function of both stream characteristics at the bank (pool or riffle) and available cover.

Stream Channel

Substrate materials are classified into five classes by visually projecting each one-foot division of a measuring tape to the streambed surface and assigning the major observed sediment class to each division. Sediments are classified as boulder, rubble, gravel, and fine sediment. Instream vegetative cover is a direct measurement of the vegetative cover on the channel intercepted by the transect. Stream channel substrate embeddedness measures the gasket effect of fine sediment around the larger size substrate particles.

Riparian Habitat Analysis

These measurements attempt to describe the riparian interface between the aquatic and terrestrial ecosystems. This zone provides many of the habitat requirements of fish, such as cover and food. It is also especially vulnerable to alteration by livestock because such characteristics as higher forage production and palatability, shade, and even terrain tend to encourage preferential use. Annual monitoring of these data after the grazing season illustrates changes in many critical fishery habitat parameters. These measurements are subjected to the same statistical analyses as the geomorphic/aquatic measurements.



Figure 7. Using a clinometer and measuring rod to measure the angle of an undercut streambank.

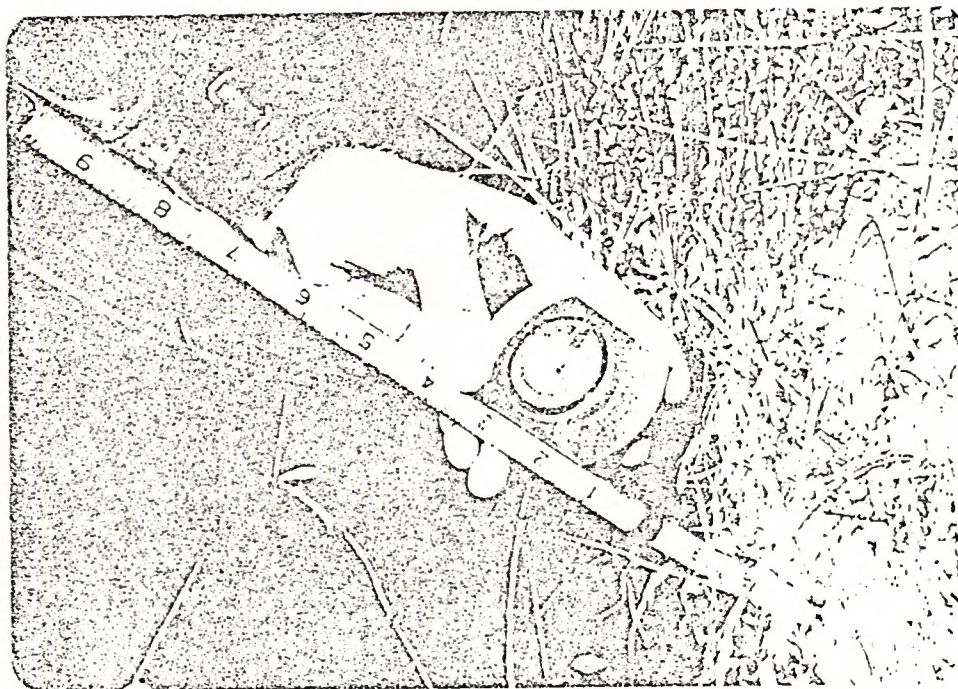


Figure 8. Close up view of clinometer illustrating an angle measurement of about 45 degrees.

Streamside cover categorizes the dominant vegetation as tree, brush, grass, or exposed. Streamside cover stability is a four group rating of the ability of the streambanks to resist erosion. Vegetative overhang directly measures the length of the vegetation overhanging the water column within 12 inches of the water surface (Figures 9 and 10). Habitat rating is based on the belief that sand banks are of least importance to fish, while brush-sod banks are of the greatest value. Intermediate types are ranked accordingly by dominant and subdominant characters. Measurement of vegetation use is done both by ocular assessment and with an electronic capacitance herbage meter.

Streamside Herbage Analysis

In order to provide a quantitative complement to an ocular vegetation use assessment, a Neal Electronics model 18-2000 herbage meter is used to measure standing vegetation. A double-sampling technique is used in which primary readings are taken at approximately every fourth transect, and linear regression analysis of meter readings against green weight of clipped plots in the secondary sample provides a quantitative estimate of forage biomass and use.

Hydraulic Geometry and Stream Channel Analysis

Ten transects in the central section of each 600-foot stream reach are used for hydrologic analysis. The data obtained here allow us to generate a stream cross section map. Periodic measurement over the course of the study shows quantitative changes due to erosion and deposition of channel materials. The stakes are surveyed to detect changes in their relative positions and the water surface is surveyed to allow monitoring of changes in channel gradient.

Water Quality and Macroinvertebrate Analysis

These analyses were performed under contract for the USDI, BLM, Salt Lake District Office, Salt Lake City, Utah, and made available for our use in these studies.

Fish Population Analysis

Fish populations are sampled with either battery powered, portable, backpack mounted electrofishers or with gasoline powered, motor energized units. Salmonids are counted, measured, and weighed, while non-salmonids are counted and weighed as a group. All are handled as carefully as practicable, and promptly returned to the stream alive. Fish population estimates are obtained for each species encountered using a four-step maximum likelihood depletion model.



Figure 9. Using a measuring rod to measure overhanging vegetation, an important source of fish cover.

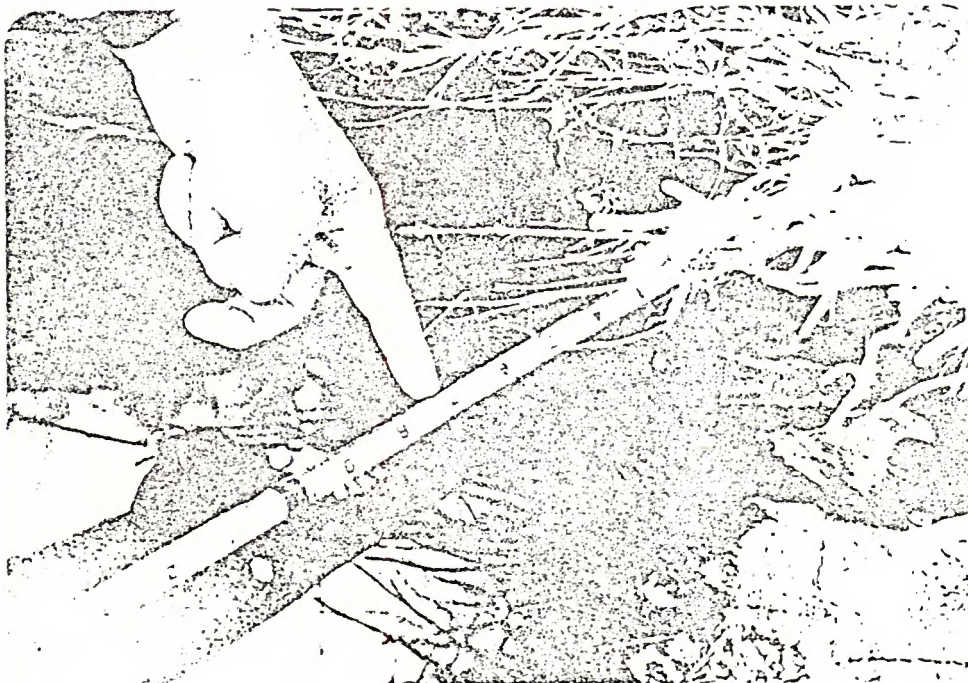


Figure 10. Close-up view of the measuring rod illustrating a vegetative overhang measurement of about 1.5 feet.

RESULTS

Geomorphic/Aquatic Analysis

The 1980 stream habitat condition variable means, their 95 percent confidence intervals, and an indicator of significance in the differences between treatment and combined control means are presented in table 2. Means for both 1979 and 1980 are presented for comparison in table 3.

Water Column

In general, Big Creek presents a classic picture of the differences between grazed and ungrazed aquatic and riparian habitats. Inside the ungrazed exclosure, Big Creek is significantly narrower and deeper with significantly more pool areas of higher quality than the grazed area outside the exclosure. The difference in pool feature, however, indicates that gabions may be influential in controlling the pool/riffle ratio.

Streambanks

Streambank contact zone characteristics also show the effect of reduced grazing in the exclosure. Bank undercuts average almost twice as deep in the treatment area; average bank angle is significantly reduced, and bank water depth is significantly greater. These traits are all reflected in the fisheries rating, which is almost maximal in the treatment area but not very high in the control areas. The presence of gabions, however, will also tend to increase the fisheries rating in the treatment area because of the greater amount of pool at the contact zone.

Stream Channel

Substrate conditions do not, at first glance, appear to exhibit this classic picture since small fines are significantly more abundant in the treatment area while gravel is significantly less abundant and more highly embedded. This is probably due however, to the presence of the gabions in the treatment section which may be allowing the fine sediments to precipitate out of the water column more readily, thereby embedding the larger substrate materials. Boulder and rubble are significantly more abundant in the treatment area while large fine sediments show little variation between sites. Instream vegetative cover also is significantly more abundant in the treatment zone than in the controls considered together, probably due to its scarcity in site 1.

Little time-trend analysis can be completed after only two years of study, but it appears that many of the structural parameters are in flux, though not dramatically so.

Table 2.--1980 Geomorphic/aquatic and riparian means with their 95 percent confidence intervals, Big Creek, Utah (9/3-4/80). An asterisk (*) denotes a significant difference ($P < 0.05$) between treatment and combined control means.

Variable	Site 1		Site 2		Site 3		Overall	
	Mean	Interval	Mean	Interval	Mean	Interval	Mean	Interval
Geomorphic/Aquatic								
Stream Width (feet)*	13.3	12.5 - 14.1	12.3	11.5 - 13.1	13.8	13.0 - 14.6	13.1	12.7 - 13.6
Stream Depth (feet)*	0.59	0.50 - 0.67	1.00	0.92 - 1.09	0.68	0.60 - 0.76	0.76	0.71 - 0.81
Riffle Width (percent)*	43.7	35.8 - 51.7	14.9	6.9 - 22.8	28.6	20.6 - 36.5	29.1	24.5 - 33.7
Pool Width (percent)*	56.3	- -	85.1	77.2 - 93.1	71.4	63.5 - 79.4	70.9	66.2 - 75.4
Pool Rating*	3.1	2.8 - 3.4	4.5	4.2 - 4.8	3.9	3.6 - 4.2	3.8	3.6 - 4.0
Pool Feature*	1.2	0.7 - 1.7	6.2	5.7 - 6.7	1.0	0.5 - 1.5	2.8	2.5 - 3.1
Bank Angle (degrees)*	134	126 - 141	104	96 - 111	124	116 - 132	120	116 - 125
Bank Undercut (feet)*	0.10	0.05 - 0.16	0.22	0.16 - 0.27	0.14	0.09 - 0.20	0.15	0.12 - 0.18
Bank Water Depth (feet)*	0.08	0.02 - 0.13	0.24	0.19 - 0.30	0.14	0.08 - 0.20	0.15	0.12 - 0.19
Substrate Embeddedness*	3.3	3.1 - 3.6	2.3	2.0 - 2.5	3.0	2.7 - 3.2	2.9	2.7 - 3.0
Boulder (percent)*	3.3	1.2 - 5.3	6.1	4.1 - 8.2	0.0	0.0 - 2.1	3.1	1.9 - 4.3
Rubble (percent)*	3.6	0.0 - 8.9	33.6	28.3 - 38.9	0.0	0.0 - 5.3	12.4	9.3 - 15.4
Gravel (percent)*	82.8	77.3 - 88.3	15.2	9.8 - 20.7	68.9	52.5 - 58.8	55.6	52.5 - 58.8
Fines 0.8 mm (percent)	0.4	0.1 - 0.8	0.3	0.0 - 0.7	0.0	0.0 - 0.4	0.3	0.3 - 0.5
Fines 0.8 mm (percent)*	9.9	3.1 - 16.8	44.8	37.9 - 51.6	31.1	24.3 - 38.0	28.6	24.7 - 32.5
Instream Vegetative Cover (feet)*	0.1	0.0 - 0.1	0.3	0.3 - 0.4	0.3	0.3 - 0.4	0.2	0.2 - 0.3
Fisheries Rating*	2.0	1.8 - 2.2	4.3	4.1 - 4.5	2.4	2.2 - 2.6	2.9	2.8 - 3.0
Riparian								
Bank Cover Stability*	1.6	1.4 - 1.7	3.2	3.0 - 3.4	1.7	1.5 - 1.9	2.2	2.1 - 2.3
Stream Cover*	1.4	1.3 - 1.5	2.1	1.9 - 2.2	1.5	1.4 - 1.6	1.6	1.6 - 1.7
Habitat Type*	10.0	9.1 - 10.8	15.3	14.5 - 16.2	13.5	12.6 - 14.3	12.9	12.4 - 14.4
Vegetation Utilization (percent)*	87	83 - 90	0	0 - 3	77	74 - 80	55	53 - 56
Bank Alteration-Natural (percent)	6	5 - 8	7	6 - 9	5	3 - 6	6	5 - 7
Bank Alteration-Artificial (percent)	63	60 - 66	20	17 - 23	58	55 - 61	47	45 - 49
Vegetative Overhang (feet)*	0.18	0.09 - 0.26	1.09	1.01 - 1.17	0.23	0.14 - 0.31	0.50	0.45 - 0.55

Table 3.--Comparison of geomorphic/aquatic and riparian means for 1979 and 1980, Big Creek, Utah.

Variable	Site 1			Site 2			Site 3			Overall		
	1979	1980	Δ	1979	1980	Δ	1979	1980	Δ	1979	1980	Δ
Geomorphic/Aquatic												
Stream Width (feet)	12.5	13.3	+ 0.8	11.7	12.3	+ 0.6	12.9	13.8	+ 0.9	12.3	13.1	+ 0.8
Stream Depth (feet)	0.52	0.59	+ 0.07	0.87	1.00	+ 0.13	0.66	0.68	+ 0.02	0.68	0.76	+ 0.08
Riffle Width (percent)	78.5	43.7	-34.8	42.1	14.9	-27.2	61.7	28.6	-33.1	61.2	29.1	-32.1
Pool Width (percent)	21.5	56.3	+34.8	57.9	85.1	+27.2	38.3	71.4	+33.1	38.8	70.9	+32.1
Pool Rating	1.6	3.1	+ 1.5	3.6	4.5	+ 0.9	3.1	3.9	+ 0.8	2.8	3.8	+ 1.0
Pool Feature	1.5	1.2	- 0.3	5.7	6.2	+ 0.5	1.0	1.0	0.0	2.8	2.8	0.0
Bank Angle (degrees)	136	139	- 2	113	104	- 9	138	124	-14	129	120	- 9
Bank Undercut (feet)	0.08	0.10	+ 0.02	0.19	0.22	+ 0.03	0.07	0.14	+ 0.07	0.11	0.15	+ 0.04
Bank Water Depth (feet)	0.19	0.08	- 0.11	0.59	0.24	- 0.35	0.61	0.14	- 0.47	0.47	0.15	- 0.32
Substrate Embeddedness	2.9	3.3	+ 0.4	2.2	2.3	+ 0.1	2.2	3.0	+ 0.8	2.5	2.9	+ 0.4
Boulder (percent)	0.1	3.3	+ 3.2	0.4	6.1	+ 5.7	0.0	0.0	0.0	0.2	3.1	+ 2.9
Rubble (percent)	1.9	3.6	+ 1.7	24.1	33.6	+ 9.5	0.1	0.0	- 0.1	3.6	12.4	+ 8.8
Gravel (percent)	81.3	82.8	+ 1.5	23.0	15.2	- 7.8	50.9	68.9	+18.0	51.9	55.6	+ 3.7
Fines > 0.8 mm (percent)	0.0	0.4	+ 0.4	0	0.3	- 0.6	2.3	0.0	- 2.3	1.1	0.3	- 0.8
Fines < 0.8 mm (percent)	15.5	9.9	- 5.6	49.0	44.8	- 4.2	45.8	31.1	-14.7	36.8	28.6	- 8.2
Instream Vegetative Cover (feet)	1.2	0.8	- 0.4	3.3	3.2	- 0.1	5.1	3.2	- 1.9	3.2	2.4	- 0.8
Fisheries Rating	1.2	2.0	+ 0.8	2.6	4.3	+ 1.7	1.9	2.4	+ 0.5	1.9	2.9	+ 1.0
Riparian												
Bank Cover Stability	1.7	1.6	- 0.1	3.4	3.2	- 0.2	2.0	1.7	- 0.3	2.4	2.2	- 0.2
Stream Cover	1.9	1.4	- 0.5	2.1	2.1	0.0	1.8	1.5	- 0.3	1.9	1.6	- 0.3
Habitat Type	12.9	10.0	- 2.9	15.3	15.3	0.0	11.8	13.5	+ 1.7	13.3	12.9	- 0.4
Vegetation Utilization (percent)	76	87	+11	17	0	-17	73	77	+ 4	56	55	- 1
Bank Alteration - Natural (percent)	13	6	- 7	12	7	- 4	10	5	- 5	12	6	- 6
Bank Alteration - Artificial (percent)	29	63	+34	4	20	+16	24	58	+34	19	47	+28
Vegetative Overhang (feet)	0.07	0.18	+ 0.11	0.57	1.09	+ 0.52	0.12	0.23	+ 0.11	0.25	0.50	+ 0.25

Riparian Habitat Analysis

The 1980 riparian analysis means, their 95 percent confidence intervals, and an indicator of significance in the difference between treatment and combined control means are presented in table 2. Means from both 1979 and 1980 are presented for comparison in table 3.

Riparian characters also reflect the positive effect of the Big Creek enclosure on aquatic and riparian habitats. The habitat ranking in the treatment area is significantly better than in the control sites, probably due to the presence of more brush and sod with reduced amounts of bare ground. Stream cover and bank cover stability rankings are also significantly higher in the treatment area while vegetation also overhangs the stream in the treatment area significantly more. Streambank alteration is much greater in the control sites, particularly artificial alteration. Vegetation use is not occurring within the enclosure and occurred at similar rates in the two control sites.

Time-trend information with just two years of data precludes definite conclusions in riparian habitat at this time. Slight improvements or, at least, stable conditions, appear to exist in the treatment area which are not apparent in either of the control sites.

Streamside Herbage Analysis

Figure 10 presents the herbage meter regression lines (linear calibration) and relevant statistics based on the regression of green vegetation weights on meter readings for 1979 and 1980. From these it can readily be seen that our double-sampling technique provides an effective, accurate method of estimating vegetation weights in the unclipped samples along the transect lines. The high correlation coefficients (r) are highly significant ($P < 0.01$) for both years, with the proportion of the variation in Y (weights) due to its regression on X (meter readings) never less than 0.88 (r^2). Of additional interest is the parallel nature of these two lines; the fact that such close agreement in calibration could be achieved in two different years is taken as further indication of the validity of our herbage meter technique.

Table 4 gives estimated average ^{6/}vegetation weights per sample plot and total biomass in pounds per acre^{6/} for each year in the riparian

^{6/}We are using the term "biomass" rather than "production" to avoid confusion. Production is defined as the total elaboration of vegetal tissue and is assumed to be equal in the grazed and ungrazed pastures, whereas biomass is the amount of vegetal tissue on site at the time of analysis; therefore, protected biomass (production) less grazed (remaining) biomass equals utilization. We are, however, considering only biomass contributed by new growth.

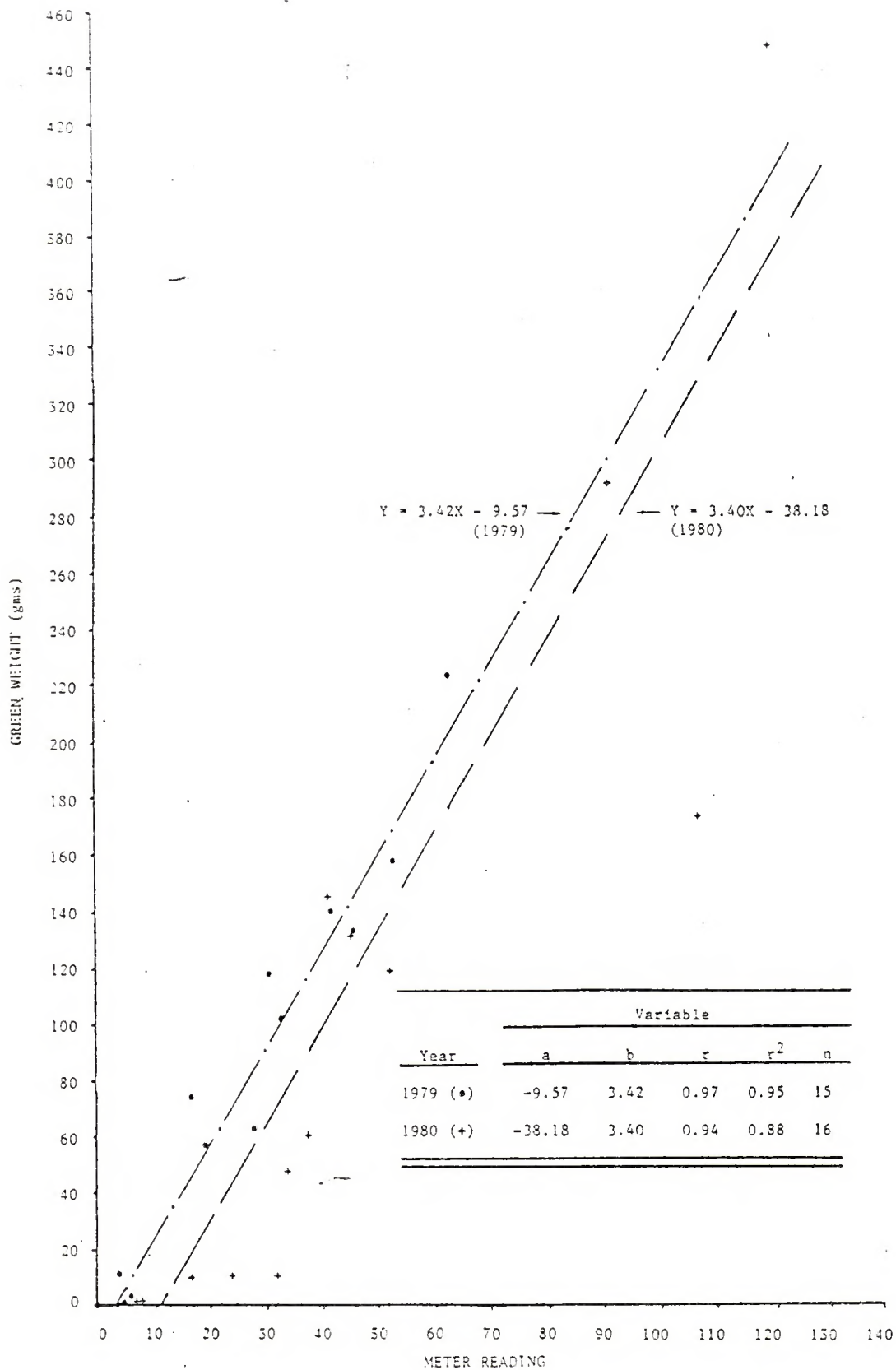


Figure 10. Streamside herbage analysis regression statistics and linear calibration lines for 1979 and 1980, Big Creek, Utah.

zone, along with a percent vegetation utilization estimate based on the difference in biomass between grazed and protected sites. Herbage evaluation was performed in October in 1979 and in September 1980, so the lower average biomass figures observed in 1980 are probably the result of different phenological stages of the vegetation. Comparison of the meter method of percent utilization with visual estimation (Table 5) reveals that agreement between the two methods is satisfactory in that the difference does not exceed 15 percent. For both years the ocular estimate is lower than the meter estimate, which is probably because the meter registers biomass differences that are not visible, including reduced production because of past use.

Table 4. Herbage weight, biomass, and use at time of sampling by site for 1979 and 1980, Big Creek, Utah

Year	Site	Management	Variable		
			Mean Weight (gm)	Mean Biomass (lb/ac)	% Use
1979 ^{1/}	1	grazed	14.9	715	84
	2	protected	93.0	4464	0
1980	1	grazed	0	0	100
	2	protected	195.8	9398	0

^{1/} Those familiar with Progress Report 1 will note that these data have been changed. Results presented in that report were found to be incorrect and have been corrected here. If you have Progress Report 1 in your files, we hope you will correct this error.

Table 5. Comparison of ocular and herbage meter use estimates in site 1 for 1979 and 1980.

Year	Vegetation Use	
	Herbage Meter	Ocular
1979	84	73
1980	100	88

Additionally, the meter will record biomass as zero when it becomes electrically indistinguishable from the soil. Thus, a use estimate of 100 percent determined by meter analysis can result when some vegetation still remains but is unusable to stock; this will not occur with the ocular estimate. Of particular interest in this analysis is the great difference in biomass between 1979 and 1980. We feel that this is attributable largely to the fact that sampling in 1979 was performed in October following peak production and moisture content whereas the sampling in 1980 was performed in early September, closer to the period of peak biomass production; since we must take these measurements as close to the cessation of grazing each season as possible, this inconsistency will be unavoidable but inconsequential in regard to utilization estimates.

Hydraulic and Channel Geometry Analysis

Hydrologic surveys were not conducted in 1980. The reader may wish to refer to Progress Report 1 for results obtained in 1979.

Water Quality and Macroinvertebrate Analysis

This topic was not addressed in Progress Report 1 because it is not a regular component of our battery of measurements. The data presented in this section were provided by Dave Bornholdt, Fisheries Biologist, USDI Bureau of Land Management, but responsibility for their application to this study rests solely with the authors.

Water Quality

Water quality surveys of Big Creek were conducted in the summers of 1975 and 1979 and the results are tabulated in Table 7. Only two values are available for any of the parameters and streams can be expected to exhibit certain natural fluctuations in these characteristics; nevertheless, some of the changes that appear to have occurred in important parameters are sufficiently dramatic as to merit some comment. Among these are turbidity, carbonate, and copper, a common heavy metal contaminant, which declined from a potentially dangerous level to virtual absence. Less dramatic changes were detected in total dissolved solids (TDS), total hardness, alkalinity, pH, bicarbonate, and nitrate, all of which declined slightly. The heavy metals, lead, mercury, iron, zinc, copper, chromium, cadmium, and manganese are all present in various concentrations, but, except for the dramatic decline in copper and a modest gain in iron, they have remained relatively stable.

In general, it can be safely stated that the water in Big Creek is relatively hard, turbid, and somewhat alkaline, though none of these parameters are necessarily excessive. Some concern, however, can be

Table 7.--Water quality characteristics of Big Creek, Utah, 1975 and 1979.

Parameter	Year	
	1975 ^{1/}	1979 ^{2/}
Turbidity (JTU)	0.74	28
Total Coliform (#/100ml)	6	112
Fecal Coliform (#/100ml)	0	93
pH	7.66	8.44
Conductivity (mhos/cm)	490	350
Tot. dissolved solids (mg/l)	319	210
Dissolved oxygen (mg/l)	ND	5.4
Tot. hardness as CaCO_3 (mg/l)	188	175
Alkalinity as CaCO_3 (mg/l)	186	193
Bicarbonate as HCO_3 (mg/l)	225.40	187
Carbonate as CO_3 (mg/l)	0.01	6.0
Phosphate as PO_4 (mg/l)	0.12	0.11
Nitrate as NO_3N (mg/l)	0.19	0.12
Sulfate as SO_4 (mg/l)	9.70	1.0
Aluminum as Al (mg/l)	0.08	0.84
Arsenic as As (mg/l)	0.01	0.007
Barium as Ba (mg/l)	0.06	0.38
Boron as B (mg/l)	0.01	5
Cadmium as Cd (mg/l)	0.001	0.003
Calcium as Ca (mg/l)	52.0	50
Chloride as Cl (mg/l)	10.0	6.9
Chromium as Cr (Hex, in mg/l)	0.01	0.5
Cyanide as Cn (mg/l)	0.01	0.01
Copper as Cu (mg/l)	0.05	0.001
Fluoride as F (mg/l)	0.12	0.10
Tot. Iron as Fe (mg/l)	0.15	0.35
Filtered Iron as Fe (mg/l)	0.08	0.04
Lead as Pb (mg/l)	0.02	0.013
Magnesium as Mg (mg/l)	13.92	11.5
Manganese as Mn (mg/l)	0.02	0.022
Mercury as Hg (mg/l)	0.001	0.005
Potassium as K (mg/l)	0.60	0.15
Selenium as Se (mg/l)	0.01	0.001
Silica as SiO_2 (mg/l)	10.0	1.2
Silver as Ag (mg/l)	0.001	0.002
Sodium as Na (mg/l)	9.49	5.6
Zinc as Zn (mg/l)	0.01	0.005

^{1/} Analysis performed by Ford Chemical Laboratory, Inc., Salt Lake City, Utah.

^{2/} Analysis performed by Pioneer Laboratory, Inc. Pensacola, Florida.

^{3/} ND = No data available

attached to the levels of phosphate, nitrate, and dissolved oxygen (DO), the former being high and latter two rather low. The phosphate and nitrate levels may be explained by the geology of the watershed which contains uplifted marine sediments and probably includes part of the Paleozoic phosphoria formation that forms the phosphate fields of south-eastern Idaho. Platts and Martin (1978) found streams draining these areas in Idaho to possess similar concentrations of phosphate and nitrate, with phosphate in the range 0.09 to 0.11 mg/l and nitrate in the range 0.1 to 0.21 mg/l. This concentration of phosphate is considerably above the 0.1 mg/l level known to be conducive to high biotic production (McKee and Wolf 1971) and the 0.05 mg/l total phosphorous level recommended as the upper limit that should be allowed in streams flowing in to lakes (Federal Water Pollution Control Administration 1968). The nitrate concentration, however, is relatively low and may be a potential limiting factor in fish production; according to McKee and Wolf (1971) only 5 percent of the waters in the United States supporting good fish populations have nitrate concentrations less than 0.2 mg/l. Dissolved oxygen may be another potential trouble spot because of its apparent low level, which is near the 5.0 mg/l level that is needed to maintain a good, mixed fish fauna (McKee and Wolf 1971).

Temperature

Temperature monitoring took place within the livestock enclosure in 1977 and 1978, though measurements were taken in the spring of 1978 and the summer of 1978. As a result, no comparison between the two years is possible. What is clear is that temperatures in May can be as low as 36°F (2°C) and as high as 61°F (16°C), with a mean high of about 54°F (12°C). In the summer of 1978^{7/}, temperatures never dropped below 45°F (7°C) and reached as high as 70°F (21°C), with a mean high and low of 66°F (19°C) and 53°F (11.5°C) respectively. Although these temperatures are within healthy limits for trout, the highs are well above the rainbow trout optimum of 55°F (13°C) (McKee and Wolf 1971); this consideration assumes additional significance when the depleted oxygen concentration is taken into account because more oxygen is required by fish at the warmer temperatures.

Macroinvertebrates

Macroinvertebrate surveys were made in 1976, 1977, and 1978 and the results are displayed in Table 8. There appears to be some seasonal

^{7/} Big Creek macroinvertebrate analysis performed by USDA Forest service, Region 4, Aquatic Ecosystem Analysis Lab, Uinta National Forest and on file with USDI Bureau of Land Management, Salt Lake District Office, Salt Lake City, Utah.

Table 8. Macroinvertebrate characteristics of Big Creek in 1976, 1977, and 1978^{1/}.

Variable				
Sample Date	Mean Diversity Index (DAT) ^{2/}	Quality ^{3/} Rating	Mean Standing Crop (gn/m ²) ^{2/}	Quality ^{3/} Rating
9/10/76	13.6	Good	10.45	Excellent
6/29/77	9.4	Fair	2.66	Good
8/30/77	10.5	Fair/Good	6.62	Excellent
6/13/78	10.6	Fair/Good	12.74	Excellent
8/23/78	14.0	Good	2.33	Good

^{1/} Analysis performed by USDA Forest Service, Region 4, Aquatic Ecosystem Analysis Lab, Uinta National Forest.

^{2/} Average of mean, for three sampling stations.

^{3/} Scale used by Region 4 USDA Forest Service, Aquatic Ecosystem Analysis Lab, Uinta National Forest.

fluctuation in both diversity and standing crop, with 1978 values higher than those of the two previous years. According to the lab report, "each station had some species bordering on clean water requirements so riparian habitat improvements could show positive results in a relatively short period of time".

Fish Population Analysis

Table 9 lists the results of the 1980 fish population survey of Big Creek, which are compared with corresponding results from the 1979 survey in Table 10.

Big Creek continues to possess relatively few game fish per unit area, including fewer rainbow trout than in 1979. This reduction in the number of rainbow trout, however, is compensated by an influx of cut-throat trout, probably a result of passive drift from upstream during the unusually heavy runoff in January, 1980^{8/}. The large average fish size found at all sites for both species of trout indicate that very little natural reproduction of game species occurs under present conditions. The presence of the livestock enclosure has little apparent effect on the fish populations in the treatment site, which continues to possess the smallest fish standing crop. This statement may not be entirely correct because there is no before-the-fact (pre-enclosure) fish population data for comparison. Interestingly, however, fluctuations in game fish abundance have not been as great in the study area, though species composition has changed. These circumstances may be due to the gabions which have created more and higher quality pools, but have also promoted considerable deposition of sediment in the site, therefore, the negative effects of the increased sedimentation may be more significant to the fishery than the improvements in pool-riffle ratio and bank characteristics. Without before-the-fact data this thinking cannot be validated until most time-trend information is obtained.

Non-game species continue to dominate the fish community of Big Creek. Sculpin numbers were higher in 1980 than 1979 over the complete study area and are most abundant where game fish are also most abundant (site 3). Suckers, on the other hand, have declined in abundance, though they also reach peak abundance where game fish numbers are not maximal. Sculpin are the most successful fish in populating this reach of Big Creek under present conditions.

^{8/}Pitman, D. 1981. Personal correspondence, Utah Division of Wildlife Resources, Northern Regional Office, Ogden, Utah.

Table 9.--Fish population analysis results for 1980, Big Creek, Utah. Data provided by Utah Division of Wildlife Resources, Northern Regional Office, Ogden, Utah.

	Total No. Collected	Mean Length (In.)	(mm)	Mean Weight (Oz.)	(gm)	Population Estimate	95% C.I. ^{1/}	Standing Crop No/ft ²	Crop No/m ²
Rainbow Trout									
Site 1	9	10.1	257	6.1	172	N.A. ^{2/}	0	0.0011	0.012
Site 2	4	9.5	242	5.2	148	N.A.	N.A.	0.0005	0.006
Site 3 ^{3/}	1	10.3	262	6.2	176	N.A.	N.A.	0.0001	0.001
Overall	14	10.0	253	5.8	165	17	13-21	0.0006	0.006
Cutthroat Trout									
Site 1	0	---	---	---	---	0	N.A.	0.0000	0.000
Site 2	3	7.1	181	2.2	63	N.A.	N.A.	0.0004	0.004
Site 3 ^{3/}	23	6.5	164	1.7	49	26	22-30	0.0028	0.030
Overall	26	6.5	166	1.8	51	28	24-32	0.0011	0.012
Sculpin									
Site 1	1395	N.T. ^{4/}	N.T.	0.1	4.0	N.A.	N.A.	0.1748	1.882
Site 2	667	N.T.	N.T.	0.1	3.6	914	785-1043	0.0904	0.973
Site 3 ^{3/}	1293	N.T.	N.T.	0.2	5.3	1319	130-1329	0.1562	1.681
Overall	3355	N.T.	N.T.	0.2	4.4	3430	3373-3487	0.1423	1.532
Sucker									
Site 1	2	5.4	136	1.1	32	N.A.	N.A.	0.0003	0.003
Site 2	6	5.1	129	1.1	30	N.A.	N.A.	0.0008	0.009
Site 3	22	3.8	97	0.9	25	30	23-37	0.0027	0.029
Overall	30	4.2	106	0.9	26	33	28-38	0.0013	0.014

^{1/} C.I. - Confidence interval

^{2/} N.A. - Not available

^{3/} Three catch effort

^{4/} N.T. - Not taken



Table 10.- Comparison of 1979 and 1980 fish population analysis results, Big Creek, Utah. 1980 results supplied by Utah Division of Wildlife Resources, Northern Regional Office, Ogden, Utah.

Species/Study Area	1979					1980				
	Population Estimate	Mean Length (mm)	Mean Weight (gm)	Standing Crop ² No./ft ²	Standing Crop ² No./m ²	Population Estimate	Mean Length (mm)	Mean Weight (gm)	Standing Crop ² No./ft ²	Standing Crop ² No./m ²
Rainbow Trout										
Site 1	5 ^{1/}	231	130	0.0007	0.007	9 ^{1/}	257	172	0.0014	0.012
Site 2	6 ^{1/}	238	138	0.0009	0.009	4 ^{1/}	242	148	0.0005	0.006
Site 3	7 ^{1/}	251	157	0.0009	0.010	1 ^{1/}	262	176	0.0004	0.004
Overall	18 ^{1/}	243	143	0.0008	0.009	17	253	165	0.0006	0.006
Cutthroat Trout										
Site 1	0	0	0	0.0000	0.000	0	0	0	0.0000	0.000
Site 2	0	0	0	0.0000	0.000	3 ^{1/}	181	63	0.0004	0.004
Site 3	3 ^{1/}	153	40	0.0004	0.004	26	164	49	0.0028	0.030
Overall	3 ^{1/}	133	40	0.0004	0.004	28	166	54	0.0044	0.042
Sculpin										
Site 1	946	N.T. ^{2/}	5.8	0.09	1.07	1395 ^{1/}	N.T.	4.0	0.17	1.58
Site 2	384	N.T.	6.4	0.05	0.87	914	N.T.	3.6	0.09	0.97
Site 3	1023	N.T.	5.3	0.10	1.09	1319	N.T.	5.3	0.46	4.68
Overall	2200	N.T.	5.6	0.09	0.93	3430	N.T.	4.4	0.44	4.53
Brook Trout										
Site 1	47	N.T.	24	0.002	0.023	2 ^{1/}	156	32	0.000	0.003
Site 2	34	N.T.	55	0.005	0.050	6 ^{1/}	129	30	0.004	0.009
Site 3	24	N.T.	9	0.003	0.030	30	156	25	0.003	0.029
Overall	72	N.T.	40	0.003	0.030	33	106	26	0.004	0.041

^{1/} Total catch - no population estimate available

^{2/} N.T. - Not Taken

CONCLUSIONS

The principal value of our Big Creek studies to the BLM is to apprise them of the compatibility of the past and presently used grazing system (continuous) with the needs of the riparian-stream environments. The studies indicate that the continuous grazing system is not compatible with Big Creek habitat. Continuation of the studies will determine if the proposed deferred grazing system will better meet stream habitat needs. The studies demonstrate that Big Creek is capable of rehabilitating itself under complete rest from cattle grazing.

The studies are also evaluating the effects of the instream habitat improvement structures, and findings to date suggest that the instream structures have not achieved the desired improvement of game fish populations; and, perhaps, should therefore not have been installed. We hesitate, however, to prematurely make this judgement because our time-trend analysis is beginning to indicate that the factors limiting the population are possibly more off-site than on-site. We believe that the new enclosure project that the BLM is going to initiate may reduce off-site limitations and increase game fish biomass in all of the enclosure areas. Continuation of the studies will determine if the enclosures are increasing fish populations.

An additional benefit of the study is that at the end of the 5-year period, we will be able to provide the BLM with a methodology for documenting and monitoring Basin-Range streams in relation to livestock impacts that will have known statistical validity. Because Basin-Range streams are different than Rocky Mountain streams, the family of attributes to be monitored will be different so as to meet the requirements posed by the different limiting factors in Basin-Range streams.

Our studies have indicated that Big Creek is a heavily degraded stream that requires rehabilitation. The limiting factors that we are identifying lead us to believe that the best rehabilitative approach at this time would be to increase brush cover over and around the stream. This can be accomplished with an improved grazing system, increased enclosure size, planting shrubs and protecting them from grazing, or a combination of these strategies. Our time-trend studies will determine the value and productive effects of any improvement efforts.

The Big Creek study is also benefitting us in our over-all livestock-fishery interaction studies by allowing us to compare Basin-Range streams with Rocky Mountain streams, determine impacts from various grazing strategy, and test our methodology in various types of aquatic habitat. These would not directly benefit the BLM, but in the future they can be expected to be beneficial.

With two years of study, we have progressed sufficiently far that the BLM can evaluate our efforts and determine whether our package of products is going to answer the questions needed for proper range and fishery habitat management. Is the cost buying the BLM a product worthy of the expenditure? Does the study need any re-direction to make the

product worthy of the expenditure? Would our efforts be better expended on another stream in another situation to gain other answers (as long as this effort fits our over-all study goals)? Should the study be terminated? These questions should be seriously considered by the BLM to ensure that our final package of products will be of value. Only three years of proposed study remains, so for any re-direction to be meaningful, it should be implemented now; for this study to evaluate the coming change in grazing strategy means the necessary after-the-fact data must be collected. The before-the-fact data is now sufficient.

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